Grade 8 Standards and Learning Activities

SCIENTIFIC THINKING AND INQUIRY

8.1. Broad Concept: Scientific progress is made by asking relevant questions and conducting careful investigations. As a basis for understanding this concept, and to address the content in this grade, students should develop their own questions and perform investigations.

Students:

1. Describe how scientific knowledge is subject to modification and refinement as new information challenges prevailing theories.
2. Test hypotheses that pertain to the content under study.
3. Describe how if more than one variable changes at the same time in an experiment, the outcome of the experiment may not be attributable to a change in any single variable.
4. Explain why accuracy and openness in record keeping and replication are essential for maintaining an investigator's credibility with other scientists and society.
5. Write clear step-by-step instructions (procedural summaries) for conducting investigations.
6. Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
7. Use tables, charts, and graphs in making arguments and claims in presentations about lab work.
8. Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, or temperatures, and choose appropriate units. Explain how to interpolate on analog scales.
9. Explain why arguments may be invalid if based on very small samples of data, biased samples, or experiments in which there was no control sample.
10. Identify and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given, an analogy is not apt, no mention is made of whether the control group is very much like the experimental group, or all members of a group are implied to have nearly identical characteristics that differ from those of other groups.
11. Describe the work of pioneers of physics and cosmology, such as Nicolaus Copernicus, Galileo Galilei, Johannes Kepler, Isaac Newton, Hans Christian Oersted and Andre-Marie Ampère, Dmitry Ivanovich Mendeleyev, Albert Einstein, and Lise Meitner.
12. Apply simple mathematical models to problems (e.g., formulas such as $F = ma$).

Examples

Students drop balls of varying masses from different heights. They show that in one set of trials, only the masses should be changed while height is kept constant, and in another set of trials, only the height should be changed while the mass is kept constant. They calculate the resulting forces as the balls hit the ground (8.1.3 and 8.1.12).

Students repeat the ball-dropping experiment, changing another variable. They discuss the reasons for investigating another change, their predictions, and results (8.1.5).

Students invite representatives from DC power companies to speak on energy use in DC and alternative sources of energy (8.1.6).

Students use graphs to show that when the masses and heights of the balls are changed, their acceleration by gravity is constant when dropped (8.1.7).

SCIENTIFIC THINKING AND INQUIRY (CONTINUED)

Students make ice cubes, measuring volume and temperature. They note the volume of the melted ice, its room temperature, the time it takes for melting different masses of ice, and the space that ice (as opposed to liquid water) takes (8.1.8).

Students investigate the chemical properties of different atoms and the different kinds of reactions that those atoms may have. They note the differences in their observations early on (after observing only a small sample of reactions) to those after observing a large sample (8.1.9).

STRUCTURE OF MATTER

8.2. Broad Concept: Elements have distinct macroscopic properties and atomic structures. As a basis for understanding this concept,

Students:

1. Explain that all matter is made up of atoms that are far too small to see directly through an optical microscope.
2. Construct a model of an atom and know the atom is composed of protons, neutrons, and electrons.
3. Using a periodic chart, explain that the atoms of any element are similar to each other, but they are different from atoms of other elements. Know that the atoms of a given isotope are identical to each other.
4. Diagram and describe how atoms may combine (bond) into molecules or into large crystalline arrays.
5. Know that there are more than 100 elements that combine in a multitude of ways to produce compounds that make up all the living and nonliving things in the universe.
6. Describe how elements can be classified, based on similar properties, into categories, including highly reactive metals, less reactive metals, highly reactive nonmetals, less reactive nonmetals, and some almost completely nonreactive (noble) gases.
7. Understand how an ion is an atom or group of atoms (molecule) that has acquired an electric charge by losing or gaining one or more electrons.
8. Describe how the atoms, molecules, or ions comprising an object are in constant individual motion, and explain how their average motional (kinetic) energy determines the temperature of the object, and how the strength of the forces between them determines the state of matter at that temperature.
9. Explain that the melting and boiling temperatures of a substance (element or compound) depend on pressure and are independent of the amount of the sample. (Some materials don't melt and others don't boil because they decompose as the temperature is raised; other materials don't have a sharp melting point because they are not homogeneous.)
10. Describe the contributions of the scientists involved with the development of current atomic theory, including John Dalton, Marie and Pierre Curie, Joseph John Thomson, Albert Einstein, Max Planck, Ernest Rutherford, Niels Bohr, and Erwin Schroedinger.

STRUCTURE OF MATTER (CONTINUED)	
Examples	*Students examine the chemical structures of basic carbohydrates, fats, or proteins in their daily foods. They draw the chemical structures for simple compounds contained within those foods (8.2.4).* *Students retrieve objects from their homes that are elemental, along with their labels, such as vitamins, medicines, and foods. Students list the names of elements contained and look for regularities or patterns of occurrence of certain elements in the labels (8.2.5).* *Students investigate the reactivity of some metals within a certain subgroup, such as Al, Fe, Cu, or Mg. They react these metals with water and then with vinegar, and perform a flame test on these metals (8.2.6).* *Students explore water in its three states and make connections to temperature, motion, and forces. They drop food coloring into a freezing ice cube, a beaker at room temperature, and a steaming beaker of water (8.2.8).* *Students boil 1,000mL and 100mL of water, measuring the time it takes both to reach the boiling point (8.2.9).* *Students construct models of an atom based on the properties that each scientist discovered: presence of neutrons, radioactivity, energy quanta of electrons, energy levels, and electrons jumping from level to level, etc. (8.2.10).*

REACTIONS

8.3. Broad Concept: Chemical reactions are processes in which atoms are rearranged into different combinations of molecules. As a basis for understanding this concept,

Students:

1. Discover and explain how elements and compounds (reactants) react with each other to form products with different properties.
2. Describe Antoine Lavoisier's work, including the idea that when materials react with each other, many changes can take place, but that in every case the total amount of matter afterward is the same as before (Law of Conservation of Matter).
3. Explain how the idea of atoms, as proposed by John Dalton, explains the conservation of matter: In chemical reactions, the number of atoms stays the same no matter how they are arranged, and the mass of atoms does not change significantly in chemical reactions, so their total mass stays the same.
4. Investigate and explain how during endothermic chemical reactions heat energy is absorbed from the surroundings, and in exothermic reactions heat energy is released to the surroundings.
5. Investigate and explain that reactions occur at different rates, slow to fast, and that reaction rates can be changed by changing the concentration of reactants, the temperature, the surface areas of solids, and by using a catalyst.
6. Recognize that solutions can be acidic, basic, or neutral, depending on the concentration of hydrogen ions in the solution. Understand that because this concentration can vary over a very large range, the logarithmic pH scale is used to describe how acidic or basic a solution is (each increase of one in the pH scale is an increase of 10 times in concentration).

REACTIONS (CONTINUED)

7. Recognize that indicators of chemical changes include temperature change, the production of a gas, the production of a precipitate, or a color change.

Examples

Students heat sugar in a crucible with an inverted funnel and observe carbon residue and water vapor in the funnel as evidence of the breakdown of components. They determine what happens whey they continue heating the carbon residue. Safety note: Sugar melts at a very high temperature and can cause serious burns (8.3.1).

Students react baking soda with vinegar, or aluminum foil with copper nitrate, to predict the number and configuration of the atoms (8.3.2, 8.3.3, and 8.3.7).

Students prepare 50mL of a 5 percent solution of sodium chloride (NaCl) and evaporate it to dryness to demonstrate a physical change. As salt is recovered as the residue, students determine ways by which the water could be recovered (8.3.3).

Students react citric acid with baking soda, taking the temperature to show that the reaction is endothermic. They soak steel wool in vinegar, taking the temperature to show that the reaction is exothermic (8.3.4).

Students prepare their own acid/base indicator by boiling pieces of red cabbage in water and squeezing out the juice. Students then test the acidity or alkalinity of a set of common household items, such as ammonia, vinegar, cough syrup, dish detergent, milk, water, and juices (8.3.6).

Students prepare a solution of 0.2M Epsom salt ($MgSO_4$) magnesium sulfate and a 0.2M solution of (Na_2CO_3) sodium carbonate in separate beakers. Students mix 5mL aliquots of the two reagents to demonstrate a chemical change involving the production of a precipitate (8.3.7).

DENSITY AND BUOYANCY

8.4. Broad Concept: All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept,

Students:

1. Demonstrate that the mass of an object is a measure of the quantity of matter it contains (measured in kg or g), and that its weight (measured in N) is the magnitude of the gravitational force exerted between Earth and that much mass.

2. Know that density is mass per unit volume.

3. Investigate and explain that equal volumes of different substances usually have different masses and, therefore, different densities.

4. Determine and explain that the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced; this principle can be used to predict whether an object will float or sink in a given fluid.

5. Determine the density of substances (regular and irregular solids, and liquids) from direct measurements of mass and volume, or of volume by water displacement.

DENSITY AND BUOYANCY (CONTINUED)	
Examples	*Students measure their own body masses, and then analyze the kinds of weight that they would encounter when subject to the gravity of different planets (8.4.1).* *Students submerge pre- and post-1982 pennies in water and observe the differences in volume displacement. (Pennies minted before 1982 contain much more copper than those minted at a later date.) Students compare and graph the results (8.4.2).* *Students record the mass of equivalent volumes of different liquids (e.g., water, mineral oil, isopropyl alcohol) using a graduated cylinder (8.4.3).* *Students compare buoyancy of various items (e.g., paper clips, corks, pieces of broken pencils, rubber bands, rubber stoppers, pieces of Styrofoam, wood, aluminum foil, coins) in different liquid media (e.g., water, mineral oil, orange juice, alcohol) (8.4.4).* *Students mix oil and water and compare their relative densities (which one floats and which one sinks). Then students test the densities of the solid objects separately in the two liquid media and construct a table of their results (8.4.4).*

CONSERVATION OF ENERGY

8.5. Broad Concept: Energy and matter have multiple forms and can be changed from one form to another. As a basis for understanding this concept,

Students:

1. Explain how energy is the ability to do work and is measured in joules (J).
2. Describe kinetic energy as the energy of motion (e.g., a rolling ball), and potential energy as the energy of position or configuration (e.g., a raised object or a compressed spring).
3. Investigate and explain how kinetic energy can be transformed into potential energy, and vice versa (e.g., in a bouncing ball).
4. Recognize and describe that energy is a property of many systems and can take the forms of mechanical motion, gravitational energy, the energy of electrostatic and magnetostatic fields, sound, heat, and light (electromagnetic field energy).
5. Describe that energy may be stored as potential energy in many ways, including chemical bonds and in the nucleus of atoms.
6. Explain that the sun emits energy in the form of light and other radiation, and only a tiny fraction of that energy is intercepted by the Earth.
7. Know that the sun's radiation consists of a wide range of wavelengths, mainly visible light, infrared, and ultraviolet radiation.
8. Investigate and explain that heat energy is a common product of an energy transformation, such as in biological growth, the operation of machines, the operation of a lightbulb, and the motion of people.
9. Explain how electrical energy can be generated using a variety of energy sources and can be transformed into almost any other form of energy, such as mechanical motion, light, sound, or heat.

CONSERVATION OF ENERGY (CONTINUED)	
	10. Investigate and explain that in processes at the scale of atomic size or greater, energy cannot be created or destroyed but only changed from one form into another.
	11. Compare and contrast how heat energy can be transferred through radiation, convection, or conduction.
Examples	*Students build Rube Goldberg Devices (elaborate and ridiculous devices to accomplish the most mundane tasks) in class from toys or other objects that they might have at home (8.5.2).* *Students discuss the kinds of potential energy and kinetic energy that exist as someone rolls down a hill in a car. They discuss how to drive if the road were winding, using kinetic energy and potential energy to support their answers (8.5.2).* *Students hold two balls of different sizes with the smaller one on top of the larger, such as a tennis ball and a basketball. They observe the transformation of potential into kinetic energy when the balls are dropped, as well as the transfer of energy between the balls when they hit the ground (8.5.3).* *Students consider the kinds of energy encountered by artificial satellites that orbit Earth (e.g., magnetism created through the planet's core, electrostatic energy in the atmosphere) (8.5.4).* *Students evaluate the importance of* $E = mc^2$*, and discuss the enormous amounts of energy stored in objects they encounter daily (8.5.5).* *Students examine the varying radiation that comes from the sun, and account for how each kind of radiation offers scientists a unique understanding of how the sun works (8.5.7).* *Students rub their hands together to demonstrate friction. They feel the heat produced by the computers in the classroom or any other machines that are handy (8.5.8).* *Students trace the transformations in changes in energy that occur in a CD player or mp3 player from the battery's electricity to the sound energy of the music (8.5.9).* *Students trace the path of light energy from the time it is reflected off the object until it is converted by the brain into an image that makes us think or do something (8.5.10).* *Students heat water to a boil and observe the bubbles of convection, and then they place a towel or some form of protection on the outside of the pot of water to feel conduction. They warm their hands at a distance to observe radiation (8.5.11).*

ELECTRICITY AND MAGNETISM

8.6. Broad Concept: Electricity and magnetism are related phenomena that have many useful applications in everyday life. As a basis for understanding this concept,

Students:

1. Investigate and explain that an object can be electrically charged either positively or negatively; objects with like charges repel each other, and objects with unlike charges attract each other.
2. Explain that when an electric current flows why there is always a magnetic field associated with it.

ELECTRICITY AND MAGNETISM (CONTINUED)

3. Describe the role that electromagnets play in electric motors, electric generators, and simple devices such as doorbells and earphones.
4. Explain how electrical circuits provide a means of transferring electrical energy from sources such as generators to devices in which heat, light, sound, and chemical changes are produced.
5. Know that power is energy per unit of time, expressed in watts, *W*, and 1 *W* = 1 J/s. Explain that devices are rated according to their power capacity or consumption.

Examples *Students conduct simple demonstrations of static electricity by rubbing their feet on carpet and touching a metal object or rubbing their hair with a balloon. They place the balloon close to a small stream of water running from a faucet, or attempt to move small pieces of paper with charges from the balloon (8.6.1).*

Students research and build electromagnets. They compete to see whose magnet is the most effective (8.6.3).

Students follow the path of electrons from the city generator, through power lines and school wires, into a clock. They examine the kinds of movement that electricity causes different gears to make (8.6.4).

Students interview an engineer from a DC electric company to determine the energy choices offered in the DC area (8.6.4).

Using different wattage lightbulbs, students discuss the power and lifespan of each type of bulb (8.6.5).

FORCES

8.7. Broad Concept: When an object is subject to two or more forces at once, the effective force is the cumulative effect of all the forces. As a basis for understanding this concept,

Students:

1. Recognize that a force has both magnitude and direction.
2. Observe and explain that when the forces on an object are balanced (equal and opposite forces that add up to zero), the motion of the object does not change.
3. Explain why an unbalanced force acting on an object changes the object's speed or direction of motion or both.
4. Explain that every object exerts an attractive gravitational force on every other object.
5. Know that the greater the mass of an object, the more force is needed to change its motion.
6. Explain that if the net force acting on an object always acts toward the same center as the object moves, the object's path is a curve about the force center. (Motion in a circular orbit is the simplest example of this concept.)
7. Graph and interpret distance versus time graphs for constant speed.

Examples *Students examine how brakes are applied to the moving wheels of a bicycle. They show the direction of the force against the wheel, and observe how varying the magnitude of force on the brakes causes different effects on the bicycle (8.7.1).*

FORCES (CONTINUED)	
	Students examine the different forces necessary to balance one's body on objects like a seesaw, bicycle, flat feet, or tiptoes. They discuss the changes in direction or motion of the body if one or more of those forces become unbalanced (8.7.2 and 8.7.3). *Students play a game of tabletop hockey and explain the role of unbalanced forces on the outcomes of their game (8.7.3).* *Students swing a ball tied to a string in a circle and determine which direction the ball would move in if the string were cut (8.7.6).* *Students walk at a slow, constant speed and mark the distance traveled every five seconds (8.7.7).*

WAVES

8.8. Broad Concept: Waves have characteristic properties that are common to all types of wave. As a basis for understanding this concept,

Students:

1. Observe and explain how waves carry energy from one place to another.
2. Explain how a mechanical wave is a disturbance that propagates through a medium.
3. Explain how electromagnetic waves differ from mechanical waves in that they do not need a medium for propagation; nevertheless, they can be described by many of the same quantities: amplitude, wavelength, frequency (or period), and wave speed.
4. Investigate and explain how sound in a fluid (e.g., air) is a longitudinal wave whose speed depends on the properties of the fluid in which it propagates.
5. Investigate and explain how light waves, sound waves, and other waves move at different speeds in different materials.
6. Demonstrate that vibrations in materials set up wave disturbances, such as sound and earthquake waves, which spread away from the source.
7. Recognize that human eyes respond to a narrow range of wavelengths of the electromagnetic spectrum (red through violet) called *visible light.*
8. Summarize how something can be "seen" when light waves emitted or reflected by an object enter the eye, just as something can be "heard" when sound waves from an object enter the ear.
9. Explain that waves obey the superposition principle: Many waves can pass through the same point at once, and the wave amplitude at that point is the sum of the amplitudes of the individual waves.

Examples	*Students place a small ring around a long string and try to move the ring from one end to the other by waving the string (8.8.1).* *Students wave a string under water and observe the effects that this disturbance makes (8.8.2).* *Students build musical instruments out of straws, bottles, rubber bands, drums, or pipes, or they play real instruments. They have a concert to demonstrate varying kinds of sound energies that depend on their sources (8.8.4).*

WAVES (CONTINUED)	
	Students research the phenomenon of seeing a baseball player hit the ball and hearing the sound of the crack of the bat afterward (8.8.5). *Students bang a table with a ball balanced at the other end of the table (8.8.6).* *Students compare their vision (the wavelengths they can see) with that of bees and snakes (8.8.7).* *Students create different ripple interference patterns in a water tank and observe the movement where waves combine (8.8.9).*